DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

PROBLEMS OF PROGRESS IN INDUSTRY—5

HUMAN PROBLEMS OF INNOVATION

By HONOR CROOME

Based on a study of some Scottish firms by
Tom Burns and G. M. Stalker

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PREFACE

The object of this series is to present briefly and simply the results of new research into the social, economic and technical problems of industrial progress—problems arising from automation and other advances in techniques, and problems of management and human relations. The booklets are either 'industrial versions' of academic reports that have been or soon will be published elsewhere, or short reviews of research done independently by several teams. The series is planned in the belief that responsible officials on both sides of industry feel the need to digest and use new research material but have not the time to browse through full-length volumes.

This series is commissioned and edited by the Department of Scientific and Industrial Research, which seeks only to provide a forum for responsible new thinking and to stimulate independent discussion and action, including further research. The conclusions and speculations are those of the investigators, mostly from the universities and other well-known research bodies, and they are not necessarily those of the Department.

This issue is a short account by an independent writer of the findings of a research project carried out by Tom Burns and G. M. Stalker of Edinburgh University in some Scottish firms developing new electronics products and markets. It also attempts to assess the implications of these findings in general terms as it is felt that the human problems associated with rapid expansion in established firms are not confined to the one industry studied.

This research was supported by the Department of Scientific and Industrial Research under the Conditional Aid scheme with counterpart funds derived from U.S. economic aid. The full report, 'Management of Innovation' by Tom Burns, is to be published in due course by Tavistock Publications Limited, London. This includes the results of a later study, which have already been published in 'Management in the Electronics Industry—a study of eight English companies' by Tom Burns. Copies of this second report can be borrowed from D.S.I.R. Lending Library Unit, 20 Chester Terrace, London, N.W.1.

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Illustrations by Marc

INTRODUCTION

Over the last two or three decades, roughly since the late 1930s, there has been a great quickening of technological change in British industry. Associated with this change, both as cause and as effect, there has been a marked increase in the number of industrial scientists, and especially of industrial scientists whose rôle is not merely to perform tests, answer specific practical questions, or evolve minor improvements, but to innovate, to open up new possibilities whether of production or of use. To an unprecedented extent, technical innovation is becoming a 'resource' of industrial firms, like the manual skill of operators or the administrative skill of managers. What is sometimes realized only late in the day is that this injection of a new element, this resort by firms to research and development as a continuing activity, calls for changes in the structure and method of management.

The kind of management organization and practice, including relationships between different levels of management, which will work well when a business is running on an even keel, using well-tried methods of modifying them only slightly, will not work where technical methods are rapidly changing.

This study of what happened, between 1953 and 1957, in certain Scottish firms which entered a new business field involving rapid technological development, shows what strains consequently arose in the field of management, and especially the difficulties which were encountered in acquiring the new resources of 'Research and Development' and fitting a newly recruited or newly expanded research and development group into the managerial structure. These difficulties, and the degree of success with which they were overcome, differed with particular circumstances; but they were found to be related to certain truths about working organizations which are much more widely applicable. They concern not merely managerial efficiency, but the anxieties and ambitions people bring to their jobs, and boardroom and back-room politics. In each individual case, the difficulties confronting firms looked like a matter of individual shortcomings; but when a number of individual cases were compared there emerged a picture of pressures and constraints on individuals and on groups which affected their working behaviour and their attitude to their jobs and their colleagues in a number of quite specific ways. There is nothing inevitable about this process, however—once its nature is grasped, good management can minimize its ill effects and provide the conditions for constructive and rewarding enterprise. The faster the pace of technological progress, the more useful and, indeed, the more essential, is such an understanding.

I. THE BACKGROUND OF INNOVATION

The firms on whose experience this study is based were mostly those taking part in the scheme originated by the Scottish Council (Development and Industry) to stimulate the growth of the electronics industry in Scotland. Behind this scheme, and bulking large in its founders' minds, was a particular wartime experience: that of the collaboration between the Telecommunications Research Centre, serving officers of the Royal Air Force, and all Air Staff officers. At weekly meetings (known as 'Sunday Soviets') particular pieces of equipment and particular operational problems would be discussed, informally, thoroughly and intimately. The scientist who designed equipment and the men whose lives and fighting efficiency depended upon it got to know one another's problems as they could have done in no other way; equipment was tailored to operational needs, needs suggested new equipment, and, perhaps most important, use suggested new possibilities. The Germans, whose technical ability could not be supposed inferior, had nothing of this kind. They had a Plenipotentiary for High Frequency Techniques, in charge of research laboratories; an Air Ministry opposite number specified to him—by letter—what the Luftwaffe wanted, and the specifications went out, undiscussed, to whatever laboratories were free to handle them. Not only were needs less adequately met, since they were less closely appreciated, but the new possibilities thrown up by the 'Sunday Soviet' type of contact remained unappreciated and consequently unrealized.

Could not this intimate two-way gearing of need to design, proved superior in war, be reproduced in peacetime on a deliberate, planned basis? That was the hope. This study shows what difficulties—of organization, tradition, psychology—stood in the way.

How the Scottish scheme worked

Broadly speaking, the scheme was formally designed to bridge the gap between the users of electronic products—initially, the Service departments and the Ministry of Supply—and those firms which, although potentially suitable producers, had no adequate research team or laboratories and no experience in handling development contracts. One big firm, Ferranti Ltd., Edinburgh—whose special expertise in electronics was indeed the reason for choosing this rather than some other 'growing point' of technology for the exercise—agreed to perform the functions of intermediary, or 'staging point'. In practice, the scheme works as follows. The first contact is generally between the Scottish Council and the management of a particular firm; the initiative may come from either side. The firm is told about possibilities and procedures, and its management are invited to look around the Ferranti laboratory and possibly some Government research stations. There follows, if the firm is still interested, a process of discussion between its management, Ferranti Ltd., the Scottish Council, and one of the Defence ministries, with a view to picking a development contract which suits the firm's present activities, technical capacities, and future plans. A suitable contract is one which can be handled by the firm and Ferranti Ltd. between them. When this is arranged, the new firm engages a number of design engineers who then work alongside the Ferranti group attached to the contract. When the new team has sufficiently grasped the requirements, the special techniques and the methods of co-operation involved, it moves to its own premises—where a laboratory has meanwhile been prepared—and carries on, keeping close contact, however, with the Ferranti group until the contract is fulfilled.

In time, the firm is expected to acquire development contracts by direct negotiations, and naturally hopes that more profitable production contracts will follow. But even production contracts are, in defence work, an uncertain foundation for long-run policy. The principal attraction of the scheme is the possibility of eventually applying newly acquired expertise to the commercial market. To the participating firms, as to the Scottish Council itself, the main merit of the scheme lies in its efficacy as a pump-priming operation. The initial share of a development contract can justify recruiting a design team. By working alongside the old hands in Ferranti's, that team can gain invaluable experience in appreciating the requirements, the special techniques and the appropriate methods of working together. But the last phase, the one that really matters, is that in which this experience is used to exploit the potentialities of electronics in the firm's own sector of industry and its own markets.

Such exploitation, of course, demands more than the technical designer's expertise, however outstanding. It calls for the appraisal of factors which lie far outside his special realm. Management has to consider the firm's productive resources; present and future market needs; the capital resources which might be required, and also the sources from which, and the conditions under which, these could be raised; the stresses which the finances, the employees, and the organization of the firm can bear. It has to assess the potentialities of the new techniques; the ability of the design team to evolve in time a product which can be manufactured; and the abilities, too, of draughtsmen, planning engineers, estimators, craftsmen, foremen, inspectors, salesmen and others. For all these are concerned in the successive stages by which an innovation is 'translated' from an idea to a serviceable product; from drawing board to prototype, to manufacture, to sales, to service. There is nothing about this 'translation' process which is peculiar to electronics; it is characteristic of every field of technical innovation; and this study in fact draws part of its material from elsewhere. Wherever technical innovation is introduced as a 'resource', it affects every aspect of management and every manager throughout the firm. And in so doing it affects, often uncomfortably and in ways which it is the purpose of this study to make clear, the relations of managers with one another.

Aims and obstacles

The immediate object of the Scottish Council scheme, just described, was to attract to Scotland a larger share of the research and development contracts, and the ensuing production contracts, placed by Government departments. A longer-run object was that the firms concerned should become capable of adapting the expertise thus acquired to ordinary commercial use and the improvement of their own products and processes. But the ultimate object was both less definite and more important. It was to encourage and establish a new attitude to science and research, a closer liaison between science and production; to set, as it were, a new leaven working, and so bring about conditions in which Scottish industry in general could resume the technological leadership which it won in the eighteenth century but had largely lost in the twentieth.

To all these objects, but to the ultimate object in particular, the problems of management have proved a formidable obstacle. In half the firms concerned, research and development groups were soon disbanded, or disrupted by the resignation of their leaders. Others were converted into test departments, 'trouble-shooting' teams, or production departments—useful enough, but hardly relevant to the ultimate object. The technical possibilities were there, the commercial opportunities were there, and the technologists recruited under the scheme were qualified and able. The managements concerned were not lacking in intelligence, foresight, and the will to employ new resources and seize new opportunities. Why, then, did achievement so often fall so far short of expectation?

'... *nor were the managements concerned lacking in intelligence, foresight...*'

The firms whose experience is described all had certain features in common. They were all of small or medium size. They all had a reasonably successful history—applying the usual standards of success, that is, profits, growth, good industrial relations, reputation. They all had, in positions of authority, individuals with a personal interest in scientific research. On the other hand, they were all, at the time that the scheme was introduced, feeling the draught in their markets. An actual or prospective decline in demand for the type of goods produced; a shift of techniques which put them at a disadvantage compared with larger firms having greater capital resources; the disillusioning experience of venturing, in the course of postwar reconversion, into an unsuitable field; these or similar elements appear in all their case histories. These case histories, not only before but after the firms' entry into the scheme, also show a certain lack of co-ordination between, on the one hand, decisions to embark on a new course and, on the other, the exploration of the relevant consumer markets; technical growth was not matched by anything like a comparable expansion of sales activities and research into consumers' requirements. They had all failed to grasp the fact, so strikingly exemplified in the experience of the Telecommunications Research Centre, that innovation calls for an intimate mutual gearing of users' needs and technical possibilities; which implies in turn a transformation and expansion of sales activities hardly less radical than that of technique. Discovering users' and potential users' latent demands, pinning down their specific requirements or dissatisfactions, eliciting their possibly fruitful suggestions—as was done at the 'Sunday Soviets'—is a salesman's job, but it is a job as different from routine commercial travelling as research itself is different from routine production. Failure to transform and develop sales policy is part of the general managerial failure to integrate the element of innovation into the firm.

What innovation comprises

Innovation—'research and development' in the sense with which this study is concerned—means more, it must be repeated, than the use of laboratories and 'research departments' for routine testing or technical trouble-shooting; or the use of designers, however highly qualified, who are expected to produce designs for immediate manufacture. It covers a much bigger segment of a much longer process; the 'translation' process, already referred to, which begins with pure science and ends with an article or a service—better, cheaper, or entirely new—in satisfactory use. Roughly speaking, the starting point, what requires to be translated, is the *pure research* typical of university departments of natural science; research carried on out of detached scientific interest, without regard to practical usefulness. This shades into what is generally called *basic research*, the kind of thing done by Government research establishments and some large firms—directed towards obtaining knowledge which will one day prove useful, but not to answering immediate practical questions. Basic research in turn shades almost imperceptibly into *technological* or *industrial research*, which applies the findings of basic research or pure research to particular ends. It may involve looking for an answer to a definite question: which micro-organisms, for instance, could produce effects similar to those of penicillin?—a question whose answer provides the basis of the antibiotics industry. Or it may spring from the realization that scientific information of apparently only theoretical interest can serve an industrial or commercial purpose—atomic energy being one outstanding example, another being the application of digital or analogue computer systems to the control of machine tools. And lastly there is the work of *development*, the further translation of an idea, technically valid in itself, into a detailed practical design; the design of an article which a factory, with its limited resources of power, mechanical equipment and technical skill, can turn out in sufficient quantities and sufficiently cheaply to make the whole venture profitable.

It is with the latter two phases, industrial research and development, that this study is concerned. To embark on these sorts of activity at all, a firm must have on its staff people of a certain kind, having different qualifications and training from those of the man who is simply a qualified engineer or chemist; people who command techniques only recently grown out of pure and basic research, who are at home among its ideas, who speak its language, and who can maintain their intellectual contact with its practitioners. Somehow the firm must integrate them into its working structure. And that is where the trouble begins.

II. THE PROBLEM OF MANAGEMENT STRUCTURE

When studying the impact of innovation—especially innovation in this sense—on management, one needs first to look at the working of the managerial system as it is before the impact occurs. In firms working in reasonably stable technical conditions, there is usually a formal structure of authority whose simplest form shows lines of command running down from the managing director or general manager to departmentally or functionally specialized managers who in turn have authority over deputies and foremen; such structures can generally be laid out on a chart, with the appropriate title in each box—but the charts rarely represent the real practical working of the structure, and the titles do not mean the same thing from firm to firm. (The title 'works manager', for instance, obviously means something different in terms of work done, according to whether the firm does or does not also have a personnel officer or a production controller.) What matters is not so much the formal shape of the chart, and the formal content of the titles, as the system of working relationships which the chart symbolizes.

One structure that worked smoothly

In contrast to the firms whose experience is the main concern of this study, it is worth looking at one outside the electronics industry, in which this correspondence was almost ideally close and straightforward. This firm produced rayon filament yarn, using processes which, though certainly once 'advanced' and the product of scientific discovery, had been thoroughly assimilated into routine production.

Production started with the intake of raw materials (cellulose, carbon bisulphide, sulphuric acid, etc.) and the first stage was the arrangement of the stored cellulose sheets into batches of uniform weight. From the weighing machine the cellulose was hand-carted to a vat of caustic solution in which it was steeped for a certain time; after steeping, it was pressed between plates by a hydraulic ram, then carted and fed into the mechanical kneaders. The shredded cellulose was then stored for two or three days in mercerizing rooms, to ensure a homogenous moisture content, before the next process, where it was mixed with carbon bisulphide in mechanical churns. The resulting product, cellulose xanthate, was dropped through chutes into mixers, in which it was dissolved in a solution of caustic soda and mixed into a homogenous fluid—viscose. This viscose was then stored under vacuum to remove bubbles; filtered; and stored again in charge tanks.

This completed the preparatory phase. The next, central stage consisted in pumping the viscose through a multiple jet into a bath of sulphuric acid, from which it emerged as solid fibres. These were drawn up over a wheel, twisted into thread, and passed down into a spinning pot in which the thread was built up into cylindrical cakes. The cakes were then washed with neutralizing solutions and water, dried in heated lockers, inspected, weighed and despatched.

This sequence was a matter of mechanical and muscular efforts and of chemical action, each transforming or 'translating' the raw material a stage further. Alongside it, there took place a set of other actions, mostly a matter of human judgement though some were automatic, designed to keep the sequence running properly and smoothly. The spinning machine was automatic, but was tended by workers who stopped and started it in order to renew broken threads, remove completed cakes and replace empty pots. Thermostatic apparatus controlled heat and humidity in the mercerizing rooms and kept a record; workers were employed to inspect these and other records and report fluctuations outside a certain latitude. Samples were taken every hour from the baths of sulphuric acid; these were analysed in the laboratory, and any fluctuations beyond certain limits were noted and resulted in instructions to the foreman in charge to vary appropriately the input of sulphuric acid. At all stages these controls aimed at keeping the processing changes, and the conditions affecting those changes, within a range of permitted tolerances and as close as possible to a set of ideal constants.

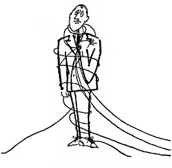
These constants and tolerances were set down in a book (known as the 'Factory Bible') which was in the hands of every departmental head. It enshrined the norm to which it was everyone's duty to make that part of the process for which he was responsible conform. The process of correcting deviations might be extremely simple; the simplest corrections of all were automatic (thermostatic control). Almost as simple were the actions of a single worker replacing a clogged jet; the laboratory tests were rather more complex, and certain adjustments designed to reconcile technical variations with the production programme involved an elaborate system whose operation took up most of the works manager's time. At the top, the general manager in turn reconciled variations in the operation of production—by means of his control over the various sections within the works—with the requirements of the sales and costing departments and the board of directors.

The whole concern, in fact, can be seen as a three-sided pyramid of power, technical expertise, and knowledge of circumstances. At every step down from the top there was less authority, less technical expertise and less information. At every step, correspondingly, each person's task was clearly laid down and defined by his superior. He knew just what he could do in normal circumstances without consulting anyone else; just what point of deviation from the normal he should regard as the limit of his competence; and just what he should do when this limit was reached—i.e. report to his superior. The whole system was devised to preserve normality and stability. The downward flow of instructions and orders, and the upward flow of reports and requests for such instructions and orders, were precisely and clearly channelled; it had the characteristics of a smoothly working automatic machine. Since everyone knew both his job and its limits, there was little consultation; contacts ran up and down, from subordinate to superior and vice versa, and the great majority of those contacts resulted in the giving of definite orders. The outstanding characteristic of the structure was that it was mechanical and authoritarian. And it worked very well.

Two structures that worked badly

Compare with this the far from smooth working of two firms, both involved in the electronics scheme, where in the nature of things there could be no pre-existent system of constants and limits to which every individual could refer his responsibility. Here, in interview, is an executive concerned with the design, production and sale of an advanced product; his department produces designs, controls progress through the works, buys in stock and parts, and runs a separate assembly plant, using components produced elsewhere in the works. He has been having trouble in sales and production; and he ascribes these troubles precisely to the lack of a clearcut, up-and-down, structure of responsibility.

> 'Well, to my mind, the most important thing is delegation of authority and responsibility to the different levels from whoever is resident at the top. In our case it would be the managing director. Now the authority must be in line with the responsibility that you expect the individual to take . . . One man holding all the strings and under him a sound team of people who are specialists in the various fields and in the various management functions which they are to exercise . . .
>
> 'What happens in our case, the way I see it, is that this top management layer is missing and you're jumping virtually from managing director to a number of senior technicians in charge of section . . . who haven't got anyone co-ordinating their efforts except the managing director by his occasional appearances and periodic meetings . . . Now to take one instance, we do have



'. . . *one man holding all the strings . . .*'

meetings. They are fashionable now. Something goes wrong and then it's decided that a weekly meeting should take place.'

'What kind of things go wrong?'

'Well, supposing that a delivery goes wrong, or a design is put into production and is functionally not quite what it ought to be, then there is the usual post-mortem and it usually boils down to that everybody realizes there hasn't been enough control. People have gone too far and got rather wrapped up in their own particular small aspect of the overall project. It's then realized that there hasn't been any one body keeping an overall eye on things, and the usual scheme is to inaugurate a weekly meeting at which various points can be raised and discussed. Now, in theory, that's a very desirable thing so long as it discusses matters relative to its function. Also that the plan of attack for the following week's work is clearly laid down and it is stated who will do what and they report back. It shouldn't just amount to a weekly gathering of bodies who, half-way through the meeting, drink a cup of tea and then break up and that's that . . .'

'What kind of things go wrong that are not put right at such meetings?'

'Well, when you start a new design there are certain steps you must go through to get a new production batch on the go. Those steps involve the drawing office, purchasing, and planning and progress. That in turn will require examination of the capacity within the plant, machine loading and the rest . . . To get the whole thing going needs one instruction to one man who, in turn, will see that the wheels are set in motion. Well, that doesn't normally happen here. There is no one man. What it amounts to is that it's announced "Wouldn't it be a good idea if we produced another ten of such and such a type?" and everybody says "Yes, Sir, it's a jolly good idea. Let's do that." The meeting breaks up, and a few days later, for instance, I'm in the drawing office and happen to say, "What have you done about those ten units?" and they'll say "Haven't had any instructions." I say "Well, you go ahead and get the drawings printed and the schedules out". The chap in charge of the drawing office will take my word for it—*not* because he has been instructed that I will give him his instructions but because I've always done so off my own bat and I know that unless somebody tells him he'll stay put.

'That may be the first movement. The lot will go forward to purchasing. Stock control first will run through the schedules, tick off what is in stock and so forth—there is an automatic passage of the schedule through the various departments. Ultimately somebody, usually it's the stores, will say "Well, there's a hell of a lot of stuff in for the job. When are you going to start it?" Then everybody will think "When are we going to start it?" Because, at the time when I said to Charlie in the drawing office, "It's time you got your schedules out, boy," nobody said to the

> planning office, "How are we going to fit this job in?" People here are not pushing their jobs through but trying to drag them out the other end, like a surgeon with a pair or forceps trying to drag the baby out . . .'
>
> . . . 'And our own production manager has no direct control over machining facilities. Whatever he gets done in other shops he has to try to ease in or bolster his way round to try to get them in because there is nothing laid down. I mean, he would go and see the works manager and the planning people but the situation changes so fast, he wouldn't be in the picture all the time. They wouldn't keep him informed; they'd say "All right, we can put so and so in the machine shop on; you can have them." And twenty minutes later maybe something else comes up, they take his job off and put the new thing on, and nobody would tell him. So two days later he'd come back and ask how the job was getting on. They might be sorry, they might not, but it wasn't their affair really . . .'

This harassed executive saw his firm's troubles as stemming from the lack of a proper line of command. But what his account shows is that his firm had to deal with tasks which could not be handled in this way. The 'functional contact' whose absence he deplored could not possibly, given the sort of work that the firm was doing, be satisfactory if it was of a merely or even mainly up-and-down or 'vertical' kind, a matter of clear-cut authority and delimited powers.

Yet no other way was thought feasible. When the command system showed signs of strain, a progress committee had been formed as a first move towards another kind of system which would allow of a bigger, less specified contribution from the executives concerned. Even during the meetings, however, the management group had reverted to the command system. They had looked to the managing director for decisions—('Yes, Sir, that's a jolly good idea')—and for the allocation of a specific job to each of them.

The other firm had moved a good way towards devising a system which matched these new requirements. A number of minor features distinguished it from the firms so far considered. Nobody on the staff side had a title except the managing director and nobody had a cut-and-dried, limited function. Any junior could consult, or ask for a decision from, any member of the top management group. More positively and decisively a system of management had been built up which allowed industrial tasks to remain continuously fluid, and involved each executive in the whole task of the firm.

A management committee met every week; the major function of these meetings, it was declared, was to enable each member of the senior management group to reach decisions concerning his own part of the firm's task in the light of what he learned from the others and of the implications for the rest of the firm's activities. The dovetailing of individual jobs could be regarded as a technical problem and discussed in much the same way as a technical problem confronting a laboratory group.

But the management committee was not always a meeting of senior managers. It was expanded at need into a large production committee embracing almost the whole managerial staff and representatives of the different shops. This happened whenever symptoms appeared (such as a failure to hit production targets, or recourse to too much overtime) of a dislocation between the work of different departments or levels of management. At the first of any series of such meetings, complaints and criticisms would be voiced and ventilated. By the second, many of the difficulties underlying these would have been mutually settled by the people concerned; the residue would be discussed, possible solutions suggested, and more mutual adjustment would follow in the light of these discussions and suggestions. After a few meetings, the committee could shrink back to its normal size.

Essentially, the enlarged management meetings in the second firm were a response to difficulties of the same sort as those reported by the first. 'People had been going their own way and got rather wrapped up in their own particular aspect of the overall project'—they had become, in other words, preoccupied with their own particular rôles and out of touch with each other and the general task of the firm. But in the first firm any spontaneous steps by individuals, taken between meetings to put things right, were regarded as rather irregular and as a poor substitute for authoritative instruction; in the second they were normal and expected procedure. *Ad hoc* working relationships and communication in the first were almost surreptitious; in the second they were recognized as essential. When this process failed to work—as it sometimes did—the reason for the failure was fairly clear; a survival of the older notion of specialized, separate responsibilities.

'Mechanical' and 'organic' structures

Comparing the working systems of these three firms—the rayon-spinning firm with its established routine and the two engineering firms grappling with a fluid situation—one can make certain generalizations. Industrial concerns are organized as hierarchies of individuals.

In stable conditions the hierarchy can work as a 'mechanical' structure. The problems and tasks of the concern are split up into specialist functions. Each of these can be carried out separately, as a specialized responsibility whose techniques and purposes are distinct from those of the firm as a whole. Each individual rôle or job carries precisely defined rights and duties and technical requirements. Knowledge of the whole firm's needs and situation is concentrated at the top—a fact which reinforces the hierarchic, authoritarian aspect of the management structure. Contracts between members of the concern are mostly vertical, i.e. between senior and subordinate. Working activity is governed by definitions, instructions and plans for contingencies laid down by superiors.

In unstable conditions, it is not possible to split the problems and tasks of the concern into specialist functions; problems are constantly arising which call for action outside or across the boundaries of any established set of individual rôles. A number of consequences follow, or, rather, should follow. The head of the firm can no longer be regarded as an omniscient fountain-head of information, solely responsible, by virtue of his omniscience, for splitting the firm's task into individual reponsibilities. Communication becomes less a matter of giving and acknowledging orders, more a matter of mutual consultation and exchange of information; even where it involves more than one level, there is more consultation and less command. Individual responsibilities lose their clear-cut character; the individual member of the firm can no longer 'stick to his last', but must constantly relate what he is doing to the general situation and problems of the firm. He judges himself, and is judged by others, to be succeeding or failing, not according to how he is living up to a contract made with an impersonal corporation, but according to how he serves the common interest of all in the survival and growth of the firm.

If the typical successful procedure in stable conditions can be described as 'mechanical', the corresponding procedure in changing and evolving conditions can usefully be labelled 'organic'. There is no question of one being intrinsically 'better' than the other. The point is that each suits a fundamentally different set of circumstances.

III. THE PROBLEM OF STATUS

If the 'organic' type of structure is obviously the one needed under changing conditions, if the 'mechanical' type is obviously unsuitable, why is the change so slow to come? Especially, why is it so slow to come in firms which—like those involved in the electronics scheme—can show a history proving the intelligence and capacity of their management, and, moreover, show enough initiative and flexibility, when faced with market difficulties, to choose radical innovation as a response?

One answer can be ruled out right away; it is not simply a matter of the autocrat at the top clinging to power despite the protests of his subordinates. The 'command' or 'mechanical' type of structure is popular with the subordinates themselves. Everybody, when confronted with problems involving him with other people, likes to know 'where he stands'; in a mechanical structure, he does know—precisely, and with the chapter and verse of the organization chart to back him up on appeal. Everybody likes to know the limits of his responsibility, to be able to dismiss, with a clear conscience, certain things as someone else's worry. Life is quieter and more comfortable that way. The mechanical structure fulfils this need. There is, too, a deeper social and psychological reason for this preference, which comes into play in just those circumstances when the mechanical structure is becoming inappropriate. It is akin to, though not the same thing as, the sheer conservatism which is often imputed to supporters of the old regime—and which is sometimes equated, quite unjustly, with plain stupidity. It derives from the fact that to every individual concerned in a fluid, shifting situation, that situation presents not only opportunities but threats. Latent rivalries—and the mechanical structure, with each man concentrated on his specialized job and identified with that job, is essentially one of controlled and damped-down rivalries—become overt and anxious and may issue in actual conflict; relative status, power, prospects and even livelihood are uncertain. Facing such a state of affairs, it is a common trait of human nature to invoke the law, the established order, the 'done thing'. The law and the established order are, like the quiet life and limited liability, embodied in the mechanical, authoritarian structure; so instead of being discarded the structure is, however irrationally, apt to be cherished all the more.

Group 'politics' within firms

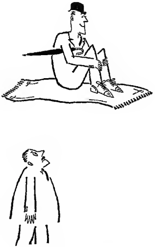
As a matter of human nature, people would in time of uncertainty probably feel the attraction of the 'done thing', the established order, the settled chain of command, even if they had absolutely nothing on their minds, consciously or unconsciously, except the desire to get on with the job and serve the firm's purposes. But a firm is not only a working organization with a working purpose. It is a community, with its own politics and its own system of rank. Everyone concerned with it is concerned with its politics—with the balance of power between the group he belongs to and other groups—and with his own rank and standing, official and unofficial.

'Politics' in this connection should not be taken to mean exclusively, or even mainly, intrigues and wire-pulling and ganging-up and other such disreputable activities. The word is used in a much wider sense. Everyone connected with the firm—management in all its groupings, workers of all grades and kinds, shareholders—is contributing something to it and has a recognized claim on its gross earnings and resources; just as every citizen has a recognized claim, one way or another, on the resources of his country. These claims compete with one another. Very obviously, the workers' claim for wages competes with the shareholders' claim for dividends and both compete with management's claim for an expansion which will reward them; only a little less obviously, the claims of one department for more space, more equipment, more staff, a bigger allocation all round, compete with the claims of other departments, just as the claims of particular social classes, particular regions, particular interests, the supporters of particular causes, compete with one another in the national field. The conflict may be carried on, in the smaller as in the larger field, with reasonable forbearance and public-spirited restraint; or it may be embittered and destructive. Inside the firm, there is little overt organization on the political party sense; but the formation of pressure groups and the quest for power are none the less familiar. 'Political' considerations constantly influence, and more or less seriously distort, courses of action concerned with the firm's primary purpose as a working organization. And they very obviously come into play when that organization is in a state of flux owing to new conditions.

Rank and prestige

Similarly with the system of rank—a matter which affects individuals rather than groups. (Political power and status and prestige are apt to go together, since the power of a group may be used to claim higher standing for its members and the exercise of power may in itself be a reward of prestige; but they are not the same thing.)

Rank and prestige are if anything more important inside the firm than outside it. Outside, the class structure is getting blurred at the edges; social differences do not jump to the eye as they once did; members of different classes are apt to live in, and stick to, different neighbourhoods, thus avoiding invidious comparisons; all in all, class distinctions have grown less obtrusive. Inside, there can be no segregation and consequently no forgetfulness on anyone's part of the social structure and his own place in it. Moreover, it is inside the work-place that occupational success, success on the job, is won or lost—and occupational success is now the basis of social advancement in general. Men wish, accordingly, not only to succeed but to be conspicuously labelled as having succeeded; and so marks of rank, so far from being blurred, are insisted upon and often deliberately elaborated. Salaries and official rank are important. But these are not enough. A has a bigger room than B; C has a carpet, D has not; E's telephone is plain black, F's is coloured; in the X office partitions are so high, in the Y



'... *C has a carpet, D has not* ...'

office they are lower—etc., etc. (This kind of symbolic distinction is not peculiar to industry, as civil servants and members of university staff are well aware.) There may be good reasons, having to do with the effectiveness of the firm as a working organization, for some of these distinctions; but in total their main purpose is to satisfy the profoundly human desire to be 'one up' on the rest of the world—or, at the very least, to avoid being 'one down'.

These are the overt mark of success; they go with promotion and position in the hierarchy; and they may be looked on as harmless vanities. But there are other ways of chalking up a score—with or without the conscious aim of beating X to the higher salary, the bigger desk or the coloured telephone. To earn recognition for doing a better job than X is one way. But to make X look ineffective may be quite equally useful; and conversely it is a good move to have something else to do on occasions when X may outshine one. A reputation may be won by ensuring that others have to adopt a placatory approach for getting information from one, or by contriving the right kind of publicity for other people's errors. The tactics are very varied and fairly familiar. The firm in which X, Y and Z are all bending more of their energies to this sort of 'one-upmanship' than to their job is obviously in a very bad way; but even in reasonably co-operative 'happy ships' it would be hard to deny that such motives are—sometimes deep below the conscious level—effectively at work. Whatever their effect on the relative rank and prestige of individuals, they obstruct effective action in terms of the working organization.

Effects on working organization

The head of an inspection department habitually produces his figures with a time-lag long enough to make them useless to the production department concerned; they serve only to show up the poor performance of the production manager. The production manager contrives, on the quiet, one weekend, to get hold of some recent figures; breaks them down usefully; and produces them at the weekly managers' meeting—where they serve not only their ostensible and quite genuine purpose of guiding his department's performance, but that of showing up the head of the inspection department. The upshot is a 'really heated quarrel' and a rupture of contact, lasting several weeks, between the two managers concerned. No doubt both parties would have quite sincerely denied the intention of using information as an instrument of rivalry.

In another instance a production engineer, who has been 'given the responsibility' for preparing the layout of a new production line, only learns at the production meeting where the layout is discussed of a prior management decision which makes his plans so much waste paper; the works manager who announces this decision has kept him in the dark—thereby maintaining his own prestige as the man who knows, the man whose superior knowledge justifies his authority. Not only is the production engineer thoroughly disgruntled; his counter-move is to withhold information himself which the works manager needs. In a situation where a considerable new technical development called for 'organic' procedures, maximum consultation and commitment to a common task—for which, indeed, the production meeting was supposed to supply the apparatus—considerations of prestige and rank had supervened. The interesting point about the effect of these self-protective tactics on the working organization is that the individuals involved revert to a caricature of the mechanical system—they 'work to rule'.

Similarly, when a mechanical system is made unworkable in stable conditions, it is converted into a travesty of organic procedures. A distaste or incapacity for the exercise of authority can create a situation in which the issue of routine instructions is converted into a bargaining arrangement; and consensus can be overvalued to the extent of being sought at the expense of doing a good job. Again, subordinates, as well as superiors and equals, can withhold information, or give it grudgingly or ironically, putting themselves in the position of one from whom advice must be sought. Or, especially where confidence in the recognition of merit has broken down, subordinates seeking promotion—or even merely wanting to get on with their jobs effectively—may try to cultivate their superiors personally and establish friendly relations which override the relationship of subordination. This may or may not deserve, in particular cases, the ugly name of 'toadying'; but it is apt to earn it—and to breed the equally ugly practice of backbiting.

Both ways, the effect is that the working organization is forced into procedures which are inappropriate to the demands of the situation.

IV. THE PROBLEM OF FITTING IN SCIENTISTS

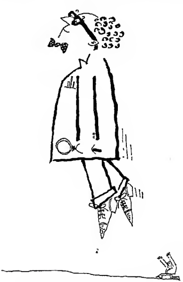
On both the 'political' and the 'status' systems of the firms concerned, the recruitment of a team of scientists for purposes of research and development had disruptive and uncomfortable effects.

The people encountering these difficulties at first hand naturally saw them as consequences of the different personalities involved, or in more sophisticated terms of different 'cultures'—like those of different races or nations, or widely separated social classes or *milieux*. 'Physicists' said one managing director, 'are very difficult people to work with.' And another: 'I've seen some of these long-haired types—they amble about in white coats, come and go as they think fit.' The popular press has built up a dramatic vision of them as 'boffins', 'back-room boys'—inhumanly clever, with an aura of wizardry, but impatient, arrogant, and suspect. On closer acquaintance, they are found to have their private jargon, their own ideas of proper working habits and social behaviour, their own scale of values for judging achievement. Inevitably, they dodge in and out of their curtains of security, even within the firm. They are, in fact, foreigners, and the difficulty of assimilating them is, to some extent, like the difficulty of assimilating any other foreign group. But the bigger difficulty arises from other causes: it has to do, not with the scientist's personal peculiarities, but with his special position *vis-à-vis* the firm and society at large, of which the 'peculiarities' are merely symptomatic.

Industrial scientists—or development engineers, or 'R and D' people—are normally graduates in natural science or engineering, who have had additional training as junior members of a team in a laboratory concerned with basic research or the development of innovations. They are valuable—both in their own eyes and as a matter of objective contemporary fact—because they stand at the centre of a constant, three-way interchange of information about basic discoveries (in electronics, biochemistry, metallurgy or whatever it may be), about manufacturing processes, and about users' needs. They become members of this group, this triple system of communications, by virtue of a tested ability to speak and understand the 'languages' in which these three sorts of information are conveyed, and to translate between them. These qualifications, this membership, are of the essence of their job. If they did not have their roots outside industry, industry would not get from them what it needs.

Scientist's attitudes

But the converse of this semi-detachment is the scientist's sense—amounting to a claim—of special, professional, extra-industrial status. He feels himself to 'belong' less to the firm he works for than to a distinctive professional group whose boundaries, within which he is (or feels he should be) free to move, extend over the universities, the technical colleges, and Government service; a group which is growing in numbers, very much in the public eye, and very conscious of its importance and of the scarcity-value of its contribution. By the same token he can ask for, and get, a salary invidiously far above those ruling for managers of equal seniority and equal or higher nominal standing. Less tangibly, but from the point of view of establishing status no less effectively, he often tries—and this is where his 'cultural peculiarities', his 'foreignness' come in—to snap his fingers at the factory's idea of normal, proper, conventional behaviour. He can 'amble about in a white coat, come and go as he sees fit'—with the



'. . . with the unspoken justification that scientists are subject to bouts of inspiration . . .'

unspoken justification that scientists are subject to bouts of inspiration which may keep them at work into the small hours. He need make no secret of the fact that accepted leisure pursuits and entertainments and works sociabilities bore him. The arts graduate in general management probably equally accustomed to working in his own time and equally bored, must learn to soft-pedal his idiosyncrasies and to accept the prevailing code of the firm; not so the scientist. He can actively cultivate them—not only as a matter of genuine preference but as a deliberate way of affirming his separateness and superiority.

Management's reactions

Very naturally these affirmations, whether incidental or deliberate, are felt as a threat to the standing of general management; and general management is apt to react in ways which make perfectly good sense in terms of self-defence but which frustrate the very purpose for which the scientists were brought into the firm. The simplest measure of self-defence is to seal off and isolate the disruptive element. One firm planned to build its laboratory on the far side of a large field, decided this was still too near, and bought premises in another part of the town. Another firm not only established its new development group some miles away but, having done so, formed it into a separate company. In a third firm the head of a laboratory group had never, after two years, so much as seen inside most of the production shops. Nor surprisingly, the work of the laboratory team in these circumstances became a matter either of particular projects leading to nothing beyond themselves, or of mere work testing and consultancy on special problems. There is little room in this compartmentalized procedure for the mutually fruitful contacts, the two-way appreciation of new possibilities, the realistic assessment of practical limitations and users' needs, which was the purpose of the electronics scheme. Leaven does not work if it is not mixed with the dough.

Metaphor and ultimate purpose aside, even the straightforward 'translation' process required by particular projects suffered. To recall the nature of this process: it begins with an idea—perhaps for meeting a felt and expressed need, maybe outside the firm, perhaps for applying a previously exploited idea in a new field; it continues with the expression of that idea in terms of theoretical engineering possibilities; these possibilities are in turn translated into practical laboratory experiments; and the results of these experiments are translated into working models. The working model is translated into a production design with parts which can—given the practical capacities of the plant concerned or of others—be manufactured or purchased and which can be assembled by production operatives; the final stages of translation consist of drawings, orders, planning schedules, and operations on machines and benches. What begins, in short, as an intricate set of mathematical and engineering symbols which only a very few, very highly trained, specialists could understand, ends up as a number of bits of metal or other materials put together, in this or some other factory, by craftsmen or unskilled operatives.

Handing over to production

Somewhere along the line, 'design brains' have to hand over to 'production brains'. In this handing over, the design must not be so altered as to affect performance; what the designers have conceived must be carried through. On the other hand their conception must correspond to something practically within the capacities of the production side.

The 'point' of handing over ought not to be a point at all, but a zone; there should be an interpenetration of the two sides, a collaborative process whereby the production side can ensure, from its first-hand knowledge of the plant's capacities and limitations, that the design is practical, and the design side can ensure, from its scientific expertise, that its essential qualities are preserved.

In reality, however, 'handing over' is treated as the transfer of responsibility across a boundary line. The situation is determined not by the needs of the working organization, but by the exigencies and forces of the political and status systems. Here is a departmental head describing how the problem of the handing-over point had been handled in his firm. In the past, he said, they had had laboratory scientists responsible for the design coming out of the drawing office into production.

> '. . . The physicists would ask for a certain accuracy and the draughtsman would promise them pretty well anything, and when it came to making the job, it was found just utterly impossible . . . we didn't have sufficient tolerances to make individual parts . . . And the materials they used weren't right in many instances; they didn't know the accuracies the machines would work to, and so on . . . In those days, when a job was developed in the lab, it passed completely from the lab to production all in one go. We'd develop and make a model in the lab workshop. This would be tested in the lab and found to be fine. Then we

> might make about half a dozen in pre-production and test them in the lab. They would all be hand-fitted, hand-made, and found to be fine. Then we'd take the job and decide to make a thousand off in production and of course the production engineer immediately rejected most of the drawings as being unfit—absolutely unfit—for production. The result was you got a tremendous gulf between the experimental side and the production side.'

The way to bridge the gap, in this manager's opinion, was to have

> 'production engineers starting with the job at a very early stage . . . he would come with the job right through the drawing office, lab workshop, pre-production and so on right on to the final production of the job, controlling it all the time . . .'
>
> 'By controlling it, what do you mean?'
>
> 'He will be ultimately responsible for the production of the job, but not for the design . . .'

Administratively, production control was further extended; requests by a laboratory project team for drawings or for machine shop or fitters' work had, under the new regime, to be passed through the member of the engineer group who was attached to the project.

The laboratory staff took a diametrically different view of the problem.

> 'Production—proper production—' said one senior laboratory worker, 'is only possible when somebody from the team goes through with it. This is what's been happening in this factory for years—I'm talking about what happens and not the theory of the thing. You can't build up from the other end.'

He went on to say that the only cases of people 'going through' with a project had been when members of the original team, some of them not up to the standard of technical ability prevailing in the laboratory, had transferred to the production side. Even a substandard laboratory worker, it was implied, was better qualified than even the best production engineer to control the intermediate zone. Without actually boycotting the production engineers whom the production side had wished on to them, the laboratory group did their best to short-circuit them and make them redundant by recruiting production specialists of their own and by loading problems of detail on to the engineering group. The blockage of communications built up by this and other issues even affected the laboratories' usefulness as a source of advice on incidental technical problems; rather than use the scientific brains under their own roof, the production side would either do the best they could on their own or refer a problem to outside agencies.

This particular example reveals the way in which status differences between laboratory and production reinforce political disputes. Those which follow fall more straightforwardly into the 'political' class. They illustrate the clash not between individual managers but between general and senior management on the one hand and the intrusive scientific element, claiming an inadmissible redistribution of power, on the other. In Firm A, markedly successful research and development, and also markedly successful—but unconnected—reform of production methods, had between them produced a situation in which both sides could put up a strong case for the investment of more resources. Most of the directors backed the production side, which they understood better and saw as more central to the firm's interests. The legitimate demands of the research and development section were met—or side-tracked—by turning it into a separate company and moving it to a distant site. There it proceeded to turn itself into a manufacturing concern on its own account. It continued to have an important interest in improving designs and finding new applications; its manufacturing activities gave it a more readily understandable claim on resources; but its 'leavening' effect on the parent concern had, in effect, been sacrificed for the sake of 'political' peace.

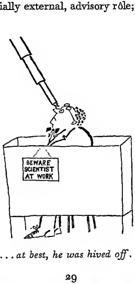
Firm B, a recently started subsidiary in the electrical industry, manufactured foreign-designed heavy equipment under licence, but had recruited as chief development engineer an industrial scientist to work on fundamental problems of design, with the aim of developing independent design resources. This technological independence was the firm's essential strategic aim; and there had accordingly been an explicit understanding, when he was brought in, that he should take over an increasing share of the general management of design and production. In fact, no room was made for him in the power structure of the concern; he remained in a consultant capacity and eventually became disgruntled and resigned.

In Firm C—where an almost exactly similar story also ended, after three years, with the resignation of the senior industrial scientist—the clash was quite explicitly over the control of resources.

> 'Everything I've put up has been blocked . . . They have no conception of what development work in this industry involves . . . they've constantly refused to put aside a certain amount of capital for development purposes . . .'

Firm D, an older industrial concern linked with the shipbuilding industry, had had some success just after the War in adapting itself to a new venture, and had been encouraged thereby to recruit an industrial scientist to explore other possibilities of innovation. In practice, however, he was given neither a laboratory nor staff (an unusual complaint) and was used at first entirely as a technical adviser on existing contracts; in effect, virtually a sales rôle. As such, he was genuinely useful. But when a major opportunity did appear, in the substitution of plastics material for the metal traditional to the industry, and he was appointed head of the department responsible for the new product, the appointment carried no share of control over the firm's general policy. Disagreeing with general management over costing, the pace of expansion, the allocation of resources, and the general matching of the firm's capacities to market needs—in none of which matters he felt himself to have a say proportionate to the real importance of his job—he eventually resigned.

All these instances have one significant factor in common; considered as part of the managerial structure, the scientists simply did not fit in. On the organization chart (that often misleading but formally useful indication of what is expected) the senior industrial scientist was given a position, as one of them said, 'sticking out in the air at the end of the line'—the line, that is, of departmental and functional managers; a position expressing the fact that no one really knew where he stood in the system of command or, for that matter, of consultation. He was in practice fitted, whatever the intention behind his appointment, into an essentially external, advisory rôle; decision-making and



'. . . *at best, he was hived off* . . .'

control over the firm's operations—including decisions and control concerning his own expert contribution—were reserved for members of the former executive hierarchy. The new functions which he exercised were not brought into management. At best, he was hived off and given a separate management unit where, successful or unsuccessful, he could not disturb the existing managerial balance of power and prestige—but was equally unlikely to act as a leaven in the concern's productive activities; at worst, frustrated and under-employed, he threw up the job.

V. THE HUMAN FACTOR IN SUCCESSFUL INNOVATION

Again and again, in the course of this study, the difficulties arising from innovation appear to have been seen by those involved in them as a matter of personalities; of obstinacy, of prickliness, of incompetence, of a whole range of personal failings. If one practical lesson emerges, it is that this explanation leads nowhere. People are often disagreeable, make many mistakes, and are insufficiently informed; but the problems arise too regularly, and in too uniform a shape, to be accounted for in terms of basic—and virtually unalterable—personal dispositions. They are best seen in terms of the triple structure of the concern as working organization, status system, and political society.

There is a sense, of course, in which the problems which formed the subject of this study can never be entirely solved. All innovation alters the relative power and status of those involved, and people who feel themselves threatened will always react, deliberately or not, so as to defend themselves. But if the nature of the problem is understood, if the source of the stresses is identified, at least the most inappropriate reactions can be avoided. Even to get away from the first, crude idea of blaming the other fellow's personality or technical shortcomings is a gain. And understanding can also prevent the automatic but pathological reaction of tightening up the command structure, the reversion to 'mechanical' organization.

The mechanical type of organization demands for its proper working (see page 16) that everyone shall have one job, clearly defined and delimited, with responsibility running up to a recognized limit and stopping there. He is not, of course, isolated; he is part of the machine;

but in so far as he has to think at all about his relations with other parts, he sees them as something outside 'his' job. They are necessary to that job only as instruments are necessary; for some data that he needs he can appeal to a slide-rule, for others he must appeal to another individual, some tasks can be performed by a tool, others through an order to a subordinate.

But this clear-cut definition of the 'job', this simple set of outside relationships all seen as accessory to that 'job', both break down when conditions are changing. New situations do not exactly match the traditional frontiers of responsibility; the individual no longer knows just what instructions are needed or where to seek them; he has to consult with, rather than merely give orders to, his subordinates.

Communication in a changing situation

This melting and shifting of frontiers, and its disconcerting effect on people used to thinking in terms of a single 'job' and of contacts consisting mainly of giving and receiving of orders, could be seen in the results of a separate study made in Edinburgh about the same time. For the purposes of the research, members of managerial groups in each of eight firms, kept a set of records in the form of printed time-sheets, one to be used for each episode occurring through every working day over a period of weeks. One of the sections of the time-sheet related to the giving and receiving of 'instructions and decisions' and of 'information and advice'. Another referred to the broad subject of the episode, e.g. costs, production difficulties, new development, personnel. (These terms were defined and agreed beforehand.)

When a set of these sheets were compared and the episodes matched up as between different accounts, it turned out that over a third of them showed wide divergences as to the subject under discussion and that, half the time, when a manager thought he was giving instructions or decisions, they were being treated by those receiving them as information or advice. These were not careless or unintelligent people talking at cross purposes. The divergence over subject matter reflected the concentration of each party on 'his' job and thus on that aspect of the matter which impinged directly on that job. Any one such misunderstanding might not matter much; cumulatively, they could have a substantial distorting effect. The discrepancy as to 'information and advice' versus 'instructions and decisions' can be seen as an assertion, on both sides, of status—the superior office mentally ticketing what he said as an exercise of authority and superior knowledge, the subordinate ticketing it as just one more datum on which to use his own independent judgement.

From both aspects—content and nature of communication—this study shows up the central fact about the mechanical organization; each individual is, for other people, one bit of the system that they are trying to administer, while for himself he is trying to administer the situation through them. At the topmost level, and there only, the 'system' is the whole firm; everywhere else it is a fragment, a 'job' which is its doer's only concern. When the 'job' loses definition, all the contacts and relationships based on the assumption that it is definite become ambiguous, uncertainly effective, and often personally strained.

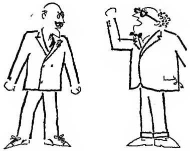
Another consequence of the crumbling of the established pattern is the need for more frequent contact between managers at the same level; willy-nilly, their roles are changing, and they must consult with one another in order to keep in the picture and co-ordinate their activities. When the time sheets kept by managers in different firms were compared, they showed that the amount of contact between such managers—by conversation and meetings, that is, apart from the routine exchange of schedules and memos—varied directly with the extent to which each firm was undergoing technical change. One firm showed a deviation from this trend; it turned out on enquiry that in fact difficulties had arisen, at about the time covered by the time sheets, for this very reason—because the managers were seeing too little of one another. These difficulties had been identified, and had been met by the institution of an inclusive meeting every morning—as it were an every-weekday 'Soviet'—for the purpose of exchanging information: not, be it noted, for the convenient distribution of orders.

These two instances show different stages of adaptation to the needs of a changing situation; the first shows questions of status and power interfering with adaptation; the second shows them overridden in the interests of the firm as a working organization.

At best, this shift to 'organic' procedures puts an extra strain on the individual. For one thing, there is the pull of the old system, the sense that a job ought to be clearly defined and that the man who steps outside its frontiers is doing something rather odd, possibly rather underhand, and certainly needing to be justified by results. (It will be remembered that the executive quoted on page 13 was evidently haunted by such feelings. He hovered uncomfortably between the clear-cut situation of the text-books, which he knew and preferred, and the course of organic co-operation which was appropriate to the firm's circumstances and which he occasionally found himself following.) For another thing, as the boundaries of the 'job' become more fluid, as it becomes less and less possible to define it according to any written contract, set of standing instructions, or book of rules, so the status that goes with it becomes indefinite too. A man's standing and prestige no longer go with his title; they depend increasingly on how he stands up to the constant mutual testing of the 'organic' procedure. What is uncertain is more of a worry. The hierarchy of status can be taken for granted in the mechanical system; in the organic system it is constantly under challenge.

Finally, the work of a manager under the organic system is more exacting. He is more fully involved as a person, more committed to the firm as a whole. He is required to devote more and more of his time and his mental capacities to matters which fall less and less within his own controllable sphere. He must, in fact, give up his safe, cut-and-dried, contractual relationship with the firm—a relationship with an impersonal, immutable 'they'—for membership of a body kept going by a shared creative activity; for the limited commitments of the nine-to-fiver he must substitute the general, open-ended commitment of the professional.

In one of the firms studied it was possible to watch this transformation being successfully carried out from beginning to end. The strain on the existing system began to grow heavy when, after a long period of experiment with a new product had ended in success and the centre of gravity of the firm had consequently swung over to innovation, a new development group was set up and very quickly became a storm centre. Older managerial groups resented it 'politically' as an intruder between themselves and top management—and the usual frictions over working habits and behaviour in general exacerbated the sore points of status. But the solution was not, in this case, the negative one so often noted of hiving off, side-tracking and playing down the newcomers. Instead, the factory manager called a meeting of both sides, bringing grievances squarely if explosively into the open, and, in the light of the clearer understanding thus achieved, revised the whole working organization. The division of the production side into small departments, each with a specific responsibility for one aspect or stage of the productive process—a limited 'job'—was dropped; and 'development groups', including departmental supervisors, charge hands and operatives, were set up instead, each with the task of solving production problems. This meant that any member of the production staff might move, not only from one stage of the process to another, but over from routine production to forming part of a problem-solving team along with either a production manager or an industrial scientist. Each job became less the performance of the limited contract, more a loosely defined, elastic range of co-operative activities; while the 'vertical' flow of information upwards and decisions downwards largely gave way to a 'lateral' flow of consultation between equals and members of teams who were equals for the time being.



'... bringing grievances squarely if explosively into the open ...'

The moral of the study

This instance is more than a single example of success; it points the general moral of the whole study—a moral applicable far outside the field of electronic development and indeed that of managerial relations. (There is a striking parallel between the change in management's idea of its 'job' in the presence of rapid development and that of the operator's idea of his 'job' when, with automation, he ceases to be a purely manual worker, an appurtenance of the single machine, and becomes a member of a machine-management group, a technical auxiliary of management.)

The moral can be summed up as follows. In the presence of rapid technical change and the strains which it imposes two natural human reactions are to be recognized and, with vigour and steadiness, guarded against and countered. One is the impulse to scurry back for safety to the 'mechanical' system, the authority of the chief and the book of rules. It is totally inappropriate. The other is to blame the personal defects and shortcomings of the individuals involved. Whether or not they contribute to the trouble, it has deeper causes.

These are negative prescriptions. Positive prescriptions must obviously be differently interpreted in every firm according to the nature of its task, the abilities of the staff, and the starting point of structure. The first and most general requirement is that management should constantly re-examine what the firm is supposed to be doing, with the conscious aim of adopting operating methods and the structure of managerial relationships to its present task. There is no question of any particular structure being absolutely 'better' or 'worse' than another; everything depends on circumstances. If the task of the firm can in fact be carried out by a number of people, each with a specific set of responsibilities and correspondingly limited liabilities, each occupying a well-established place in a pyramid of authority, so much the better; such a system, in the right circumstances, is economical and effective and has the great advantage of imposing far less wear and tear, stress and uncertainty, on individuals. But when the firm is tackling new tasks, commercial or technical, this system of differentiated routine functions will not do. Delimitations must be made fluid, responsibilities must be elastically shared. Every effort must be made to encourage the sense of the business as a whole, with objectives and goals common to all its members, rather than a complex of separate 'jobs'. The stronger this sense, the more the recourse to 'lateral' consultation, which should be recognized and facilitated, not regarded as a mere semi-legitimate supplement to the 'vertical' channels of command.

Putting these prescriptions into effect is partly a matter of organization—as in the example, cited above, of the recasting of the productive structure into development teams. Partly, also, it is a more difficult matter of tone and style; of establishing, as the 'done and recognized thing', a code of mutual good manners expressing—whatever the level of formality or informality—a spirit of co-operation and appreciation rather than the desire to score or to assert prestige. The firm should in fact regard the continuous, deliberate re-casting of its own structure, the establishment of 'organic' relationships, and the maintenance of a social climate in which these can flourish, as no less important a part of the innovating process than the building of laboratories and the recruitment of scientists and technologists.

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